sents zenithal distance of a fixed sun, the intensity of which would be 3/10 of the true intensity, and the annual effect of which would be equivalent to that of the true sun. At sea-level this quantity of solar heat is supposed to reduce itself, according to Bouguer's law, from 1 to $p^{\sec \zeta}$, where p is the mean transparence of the atmosphere.

Upon these assumptions, the *annual solar temperature* of the air on a *continental* globe is expressed (omitting here a little term for diffused heat) by a formula $t_1 = t_c + k_s \cos \zeta \frac{p^{\sec \zeta}}{m_s}$ where m_s is the transparence of the atmosphere for the earth's radiations, and k_s is a coefficient proportional to the *heating power* of solar radiation for soil, and depends then upon the physical constitution of the latter. On the sea the effect of solar heat is most complicated, but, abstracting from currents, arguments are given for accepting on *oceanic* globe a formula $t_0 = t_c + k_a \frac{p^{\sec \zeta}}{m_a}$, where m_a, k_a are the analogues of m_s, k_s for sea. Forbes expresses the mean temperature of each parallel by $t = t_0 + x (t_1 - t_0)$, when x is the fraction of parallel occupied by continents; but the same formula may express the mean temperature of every point on continents, if x means its *continentality*, whose expression by annual range e $\left(x = \frac{e - e_0}{e_1 - e_0}\right)$ is discussed.

The calculation of coefficients in the complex formulæ so obtained is very much simplified by comparison with known empirical formulæ. Mendeléef's formula for vertical distribution of temperature leads to the fundamental fact that the mean temperature of the sky, t_c, is a constant for all points at sea-level, and from evaluations of Mendeléef's constant by Woeikof I assume it as $-45°·4$ C. ($-49°$ 7 F.). So is numerically expressed what Mr. Culverwell calls the *blanketing* function of atmosphere, and its function of conforming temperature on the earth's surface; and Croll's fallacy of evaluating effects of solar heat by differences from a hypothetical temperature of space is placed in evidence. Values of t_o, t_1 at equator, discussed from Forbes' formulæ, give values of $\frac{k_s}{m_s}$, $\frac{k_a}{m_a}$; p is assumed as 0·60.

Solar temperatures so obtained give a very satisfactory representation of facts; their differences from true temperatures are a striking reflex of the distribution of meteorological and physical agents (sea and air currents, convective motions, shore-ice, &c.) not accounted for in deduction of formulæ.

An attempt is made for a theory of annual range, where Wilson's principle of the constancy of nocturnal cooling of bodies, whatever may be the temperature of the air, allows the assumption that the temperature of the sky follows in its variations temperature of soil. Comparison of theory with facts indicates the enormous smothering influence of meteorological agents.

Discussions of astronomical and geographical theory of an Ice Age, in the light of the formulæ given, accounts for variability of physical and meteorological agents. None seems to me to satisfy either the theory or the actual conditions for variation of climates, as developed *on facts* by Brückner's classical work on "Klimaschwankungen." These conditions seem to the author to be satisfied by the suggestion of a small *diminution* in the transparence p, attended by a proportional, or by a smaller, diminution of m_s, m_a. So the difference $t - t_c$ is diminished, less at low latitudes, more at higher, above all at 70° Lat., the variation diminishing further. Diminution is greater on sea and less on continent, so diminishing at high latitudes thermic difference between earth and sea, what is, according to Brückner's demonstration, the capital condition for a rainy period on continents, and indirectly for glaciers pushing forward. Also the difference between equator and poles is strengthened.

Inversely, an increase of p and m_s m_a would bring, as in Tertiary periods, a more equal distribution of temperature between equator and poles, by increasing for several degrees the temperature in higher latitudes. Mars is probably in a similar condition, as polar ice-caps do dissolve, notwithstanding that the intensity of sun is there much less than on earth; but the Martian atmosphere is extraordinarily more transparent than ours. Annual range would be strengthened; but the flora of East Siberia suggests that also Heer's polar floras might have sustained severe winter, provided that summer's heat was sufficient to support them, and that abrupt variations were avoided.

THE RÖNTGEN RAYS.

THE field of investigation opened up by Prof. Röntgen's researches on the new actinic rays has attracted explorers from all parts of the civilised world. So numerous are the communications being made to scientific societies that it is difficult to keep pace with them, and the limits of our space would be exceeded if we attempted to describe the whole of the contributions to the subject, even at this early stage. It may assist, however, in the organisation of the facts if we bring together a few of the results obtained since the publication of Prof. Röntgen's paper.

The most important British communication on the subject was made by Prof. J. J. Thomson to the Royal Society on Thursday last, in the following paper, on the "Discharge of Electricity produced by the Röntgen Rays, and the effects produced by these Rays on Dielectrics through which they pass."

"The Röntgen rays, when they fall upon electrified bodies, rapidly discharge the electrification, whether this be positive or negative. The arrangement I have used to investigate this effect is as follows: The Ruhmkorff coil and the exhausted bulb, used to produce the rays, are placed inside a large packing case covered with tin plate; this is done to screen off from the electrometer any electrostatic disturbance due to the action of the coil. The needle of the electrometer is suspended by a quartz fibre; thus, as there is no magnetic control, the needle of the electrometer is not affected by changes in the magnetisation of the core of the coil.

"The exhausted bulb is placed so that the phosphorescent part of it is about 1½ inches from the top of the box, and a hole about an inch in diameter is cut in the lid of the box just over the bulb, so as to allow the rays to emerge from the box; a thin plate of either aluminium or tinfoil is used to cover up the hole. The electrified plate, which is a little larger than the hole, is placed outside the box about two inches above the hole in the lid, so that the Röntgen rays which passed through the hole fall upon the plate. This plate is kept permanently connected with one of the quadrants of a quadrant electrometer; the greatest care is taken with the insulation of this plate and of the quadrants of the electrometer. The insulation was so good that there was no appreciable leak when the coil was not in action. The following is the method of making the experiments: The two pairs of quadrants are connected together, and the plate charged to a high potential by an electrophorus, or by temporary connection with a large battery of small storage cells. All the quadrants of the electrometer are now at the same potential. The two pairs of quadrants are now disconnected; if the insulation is good the potentials will remain the same, and there will be no deflection of the electrometer; in our experiments the leak is so small that under these circumstances the movement of the spot of light is hardly perceptible. If, now, the Rontgen rays are directed on to the plate a violent leakage of electricity from the plate occurs, the potential of the quadrants connected with the plate changes, and in a few seconds the spot of light reflected from the mirror of the electrometer is driven off the scale. This leakage of electricity occurs whether the plate is positively or negatively electrified; if the plate is uncharged to begin with, I have not been able to detect that any charge is acquired by the plate by exposure to these rays. When the potential to which the plate is raised is high the leakage from the plate is a most delicate means of detecting these rays, more so than any photographic plate known to me. I have found these rays produce distinctly perceptible effects on a charged plate after passing through a zinc plate a quarter of an inch thick. The charged plate and electrometer are much more expeditious than the photographic plate and more easily adapted to quantitative measurements.

"To determine how the radiation of the Röntgen rays depended upon the degree of exhaustion of the bulb, the bulb was kept in connection with the pump and the leakage was observed at different degrees of exhaustion; no leakage could be detected until the pressure was so low that phosphorescent patches appeared on the bulb, and, even after the phosphorescence appeared, the leakage was small as long as there was any considerable luminosity in the positive column; it was not until this had disappeared that the leakage from the charged plate became rapid.

"If the greatest sensitiveness is required, it is, of course, advisable to charge the plate as highly as possible. The leakage due to the rays, however, occurs when the potential of the plate does not exceed that of the tin-plate cover by more than 3 or 4 volts, and I have not yet met with any phenomena which suggest that there is a lower limit of potential difference below which leakage does not take place.

"This leakage differs from that produced by ultra-violet light, the laws of which have been unravelled by Elster and Geitel, in several essential features, in the first place ultra-violet light only discharges a negative charge, while the Röntgen rays discharge both positive and negative. Again, the effect of ultra-violet light is only considerable when the electrified body is a strongly electro-positive metal with a clean surface. The effects of the Röntgen rays are, on the other hand, very marked whatever the metal, and take place when the electrified plate is surrounded by solid or liquid insulators as well as when surrounded by air. I have embedded the plate in solid paraffin wax, in solid sulphur, placed it inside a lump of ebonite, wedged it in between pieces of mica, and immersed in a bath of paraffin oil; in each of these cases, though the insulation was practically perfect when the insulator was not traversed by the Röntgen rays, and the potential of the plate differed from that of the metal covering of the box by from 10 to 15 volts, yet, as soon as the Röntgen rays passed through the insulator, the charge of the metal plate leaked away. I have found that the electricity leaks from the plate even when the space between it and the nearest conductors connected to earth is entirely filled with solid paraffin; hence we conclude that when the Röntgen rays pass through a dielectric they make it during the time of their passage a conductor of electricity, or that *all substances when transmitting these rays are conductors of electricity*. The passage of these rays through a substance seems thus to be accompanied by a splitting up of its molecules, which enables electricity to pass through it by a process resembling that by which a current passes through an electrolyte. By using a block of solid paraffin in which two pairs of electrodes were embedded, the line joining one pair being parallel, that joining the other pair perpendicular, to the Röntgen rays, which were kept passing through the block, I found that there is but little difference between the rate of leakage along and perpendicular to the rays."

Prof. Thomson has investigated the question of longitudinal vibrations in connection with the recent discoveries. In a paper read before the Cambridge Philosophical Society on January 27, he discussed the theory of longitudinal waves from the point of view of the electro-magnetic theory of light, and showed that on that theory longitudinal waves can exist (1) in a medium containing moving charged ions; (2) in any medium, provided the wave-length is so small as to be compared with molecular dimensions, and the ether in the medium is in motion. It was shown that it follows from the equations of the electro-magnetic field that the ether is set in motion in a varying electric field. These short waves would not be refracted, but in this respect they do not differ from transverse waves which on the electro-magnetic theory would not be refracted if the wave-length were comparable with molecular distances. The properties of the longitudinal waves were developed in the paper. Prof. Thompson exhibited a number of photographs which had been taken at the Cavendish Laboratory by Prof. Röntgen's method, and experiments made on the Röntgen rays were described. In one of these experiments the photographic plate was placed inside the vacuum tube so as to intercept the rays between the kathode and the walls of the tube; in this case the plate was not affected, showing that the fluorescence of the glass is necessary for the production of these rays. Other experiments were made to see if they could be excited by fluorescence without a kathode; the ring discharge was produced in bulbs, and caused a vivid phosphorescence; a plate protected by cardboard when exposed to the bulb for an hour was not affected, nor was any greater effect produced when the bulb was filled with a gas such as oxygen, which phosphoresces under the discharge. It thus appears that both a kathode and a phosphorescent substance are required for the production of these rays, and that one without the other is inoperative. A series of experiments were made by taking photographs through tourmaline plates, (1) with their axes parallel, (2) with their axes crossed; it was hoped by this method to get some evidence as to whether the rays were longitudinal or transverse. A considerable number of photographs were taken in this way, but no difference could be detected in the obstruction offered to the rays by the tourmaline plates in the two cases. Another method of investigating the same question was described, based on Elster and Geitel's discovery of the influence of the plane of polarisation of light on its power to discharge electricity from a metallic surface. The experiments, which were not concluded until the day after the meeting of the Society, show that these rays exert the most powerful effect in discharging electricity, whether positive or negative, from an insulated electrified metal plate exposed to their influence. A bulb separated from the charged plate by a board three-quarters of an inch thick covered with several layers of tinfoil exerted a most powerful effect, and it was not until the thickness of the metal between the bulb and the electrified plate was nearly quarter of an inch that the effect ceased to be perceptible. The electrified plate is a much more delicate detector of these rays than the photographic one, and is more suitable when measurements are required. These results, though by no means conclusive, are in favour of the vibrations being longitudinal.

We have already mentioned, in our abstracts of the *Comptes rendus*, and in notes, the many papers which have been read before the Paris Academy descriptive of developments of Röntgen's work. In France, both the chemical and surgical sides of the discovery are being studied. As recorded in our issue of February 6 (p. 324), Prof. Lannelongue, assisted by MM. Barthélemy and Oudin, have demonstrated to the Academy of Sciences the applicability of the discovery to surgery, and observations made by Prof. Lannelongue since then bear out his conclusions that in diseases where there is an actual loss of substance in the bone, or an abnormal growth of bony tissue, photography by means of Röntgen's rays will be a valuable aid to diagnosis. The current number of the *Comptes rendus* contains several papers dealing with the chemical properties of the rays. M. Meslans has studied the influence of the chemical nature of substances on their transparency to the rays. He has found that the varieties of carbon—diamonds, graphite, and charcoal—and their compounds are easily traversed by Röntgen's rays, as also are compounds of hydrogen, oxygen, and nitrogen. Alkaloids are also transparent, but sulphur, iodine, and silicon are opaque. M. Charles Henry has found that by coating coins opaque to the rays with phosphorescent sulphide of zinc, photographic impressions of substances beneath the coins can be obtained, metals coated in this manner appearing to lose their opacity to the Röntgen rays. M. Henry has also found that phosphorescent sulphide of zinc emits, in addition to green light, a large number of the new actinic rays.

The properties of Lenard rays—that is, kathode rays which have travelled outside the tube in which they had been produced—are also being investigated. A note in the *Chemical News* states that Prof. Slaby, of Charlottenburg, has obtained good photographs by means of Lenard rays. Dr. J. Joly has also been successful in this direction of work. At the Dublin University Experimental Science Association, on February 11, he showed photographs of various objects taken after the manner of Röntgen by the Lenard rays. One of a pair of spectacles within its case showed well the transparency of wood and cardboard and the comparative opacity of glass, and the still higher opacity of the heavy metals. Experiments on refraction of the rays have in the case of paraffin oil given no evidence of refraction. This substance proved very transparent. Experiments upon the reflection of the rays have, however, yielded positive results. The rays were reflected by a silvered copper mirror on to a sensitive plate. The plate was in the geometrical shadow of a thick lead shield, the rays passing through a slot in the shield and through thick millboard before reaching the mirror, which was inclined at an angle of about 45° to the plate. Exposures of two hours gave distinct photographic effects. Reflection from a concave mirror placed behind the plate and facing the sensitive film, did not give any trace of a focus, but a darkening of the full diameter of the mirror, and rather more marked at the edge; thus suggesting irregular reflection of the rays. The experiment of Prof. J. J. Thomson on the discharge of a charged electroscope by the rays was also shown by Dr. Joly, and, at the conclusion of the meeting, it was demonstrated that this effect was not obtained at short distances from the tube, the electroscope then becoming positively electrified.

Several important letters on the subject of Röntgen rays have come to us. Lord Blythswood communicates the following, in continuation of his letter published last week:—

"Since I last wrote to you, I, at the suggestion of Lord Kelvin, placed my sensitive plate in a metal zone with an aluminium window in it. The whole was well earthed. This precaution was taken to prevent any sparking inside the zone. The zone was placed between the poles of my Wimshurst machine, and photographs of various objects taken. This is, I think, conclusive that the influence at work is not the ordinary electrical waves or discharges. For in a carefully-closed metal zone there can be no electrification, neither do the photographs of metal objects show any trace of discharge or sparking."

The following important communication on "Photography through Opaque Bodies without Crookes' Tube" has been received from Dr. John Macintyre:—

"At the demonstration given by Lord Blythswood and Dr. J. T. Bottomley before the Glasgow Philosophical Society on Feb. 5, I was requested to show some results in shadow-photography obtained by the use of comparatively simple apparatus. My remarks were then intended to show that as we became familiar with this new art the apparatus would become less complicated. As the present notes are written for another purpose I simply mention the fact that the experiments noted below were made with the same apparatus exclusive of Crookes' rube. It consisted of an induction coil giving not more than a two-inch spark, the primary coil of which was excited by four small secondary cells giving two volts each; a very small Tesla coil made by Messrs. Baird and Tatlock; and a Crookes' tube selected from the stock of an instrument-maker, but not specially prepared.

"Lord Blythswood on that occasion described the experiments published in the last issue of NATURE by means of which he was able to demonstrate that photographs could be taken without Crookes' tubes. Mr. Sydney D. Rowland in his interesting contribution to the subject in the same issue raises the question of the possibility of a 'contact phenomenon' being the explanation of Mr. Gifford's results, and not Röntgen's rays at all. As the same doubt was suggested to my mind as the result of my own experience I should like to record the following experiments which were made by me with a view of confirming the extremely interesting results recorded by Lord Blythswood. In doing so I wish it clearly understood that I do not suggest that the photographs taken through opaque bodies by Lord Blythswood were not the result of Röntgen's rays; my statements simply bear upon my own experience and the results I have been able to obtain.

"In my first experiment the sensitised paper was enclosed in a mahogany box, the sides of which were three-sixteenths of an inch thick, and the object to be photographed was a perforated zinc plate; bromide paper was substituted for glass plates in order to do away with resistance, and the whole was placed between the terminals of the small Tesla coil. The current coming from the negative pole before reaching the positive had therefore to pass through the following structures: (1) Three-sixteenths of an inch of mahogany, (2) a sheet of aluminium one-sixteenth of an inch thick, (3) the zinc plate, (4) the bromide paper, (5) some black cardboard for packing, (6) the other end of the box, also three-sixteenths of an inch. The box was insulated from the earth and held between the poles for ten minutes. On developing, a distinct image of the plate was obtained, the perforations showing black on the paper, while the part upon which the zinc rested had not been acted upon at all. It was clear from this experiment that I had obtained a photograph without a Crookes tube, and a negative—that is to say, had it been printed from the bromide paper we would have had a reproduction of the original perforated plate.

"The second experiment was different from the first inasmuch as I placed a metal plate behind the bromide paper, and consequently there was the following arrangement proceeding from the negative to the positive pole: (1) The end of the mahogany box, (2) the aluminium plate, (3) the zinc perforated plate, (4) the bromide paper, (5) a copper disc, (6) black cardboard for packing, (7) the other end of the mahogany box. This was again placed between the terminals of the Tesla coil for the same time, and the bromide paper developed in the usual way. This time the perforations did not mark the paper, but I had a distinct impression of the zinc; in other words, I had obtained a positive, because, had I printed a copy, the perforations would have appeared black, quite the reverse of the last experiment.

"It will be observed that in neither case had I, like Mr. Sydney Rowland, connected the positive pole of the coil with the metal plate behind the sensitised surface.

"On submitting these results (which were obtained previous to the date of Mr. Sydney Rowland's letter) to Lord Kelvin and Dr. Bottomley they agreed with me that the picture had possibly not been taken by means of Röntgen's rays at all; and Lord Kelvin suggested the following third experiment, in which the sensitised paper was enclosed in a metal box. In this experiment the following structures were placed in definite order between the negative and positive pole: (1) The front of the mahogany box, (2) several layers of black paper, which formed a covering for the metal box, (3) the front of the metal box, (4) the zinc perforated plate, (5) the bromide paper, (6) the metal plate, (7) the back of the metal box, (8) the black paper surrounding the metal box, (9) the other end of the mahogany box.

"It will be noticed that in this experiment the metal plates in front and behind the bromide paper were enclosed in a metal case which attracted the current round it. The result was as we had anticipated, because repeated attempts with different and prolonged exposures failed to produce any impression whatever upon the bromide paper.

"Had the photographs been obtained by the X-rays, one might have expected that while the current was conducted past the sensitised paper some impression would have been got by the Röntgen's rays piercing the metal box. As yet, however, I have not been able to obtain this result, although I have tried to with thin aluminium sheets in contact with each other at the edges and enclosing the metal plates and bromide paper.

"I should like to point out that Lord Blythswood's experiments differ from the above in many respects. He used glass sensitised plates; the apparatus was exceedingly powerful; and the objects were not placed between the terminals of the machine, but at some distance below the line of the sparks.

"From the above-mentioned experiments it is clear (1) that photographs may be taken without Crookes' tubes; (2) that different results may be obtained according to the conditions to which the sensitised surface is subjected. And I would suggest the following questions as suitable for further investigation:—(*a*) Are they not the result of a force different from the Röntgen's rays? (*b*) what is this force which is now described as a 'contact phenomenon'—a term, of course, which does not explain the actinic power? (*c*) what is the actinic power which we have hitherto considered to be a property of ordinary light? (*d*) were Röntgen's rays not generated between the metal plates?

"There is one point in this experiment which has not been touched upon by other writers, and which I should like to allude to in conclusion. It is quite clear, whether the photographs produced without Crookes' tubes were obtained by means of Röntgen's rays or not, that a current may be conducted through metal plates to a sensitised surface and impressions obtained thereon. In Mr. Sydney's Rowland's letter he makes no mention of metal plates having been placed in front of the sensitised plates. I have placed three plates of different metals in front of the object to be photographed during the time of exposure and obtained a picture, so that we have here a method of photographing certain objects through opaque bodies in the form of metal plates, and, theoretically speaking, the thickness would be a matter of comparatively little importance."

Prof. J. Wertheimer, Principal of the Merchant Venturers' Technical College, Bristol, has, at the suggestion of Mr. C. A. Morton, Surgeon to the Bristol General Hospital, taken a radiogram of an amputated foot into which Mr. Morton had introduced nine foreign bodies (bullets, splinters of needles, and glass wedges). Six of these were plainly seen on the radiogram, although Mr. Morton found that a fellow-surgeon could only locate one by palpation.

Prof. Wertheimer says: "Two points of interest arise on examination of the radiogram. Mr. Morton had endeavoured to place a fragment of needle through the last joint of the great toe on its plantar aspect. On dissecting the foot, after the radiogram had been taken, he found that the fragment had penetrated the inner corner of the distal end of the first phalanx, and had passed *beneath* the bone, leaving a small portion embedded in the phalanx itself. This fragment shows up plainly in the radiogram, and, as the foot rested on its plantar aspect, the rays must have passed through the whole thickness of the bone. The radiogram does not, however, show that the needle is *beneath* the bone. It appears, therefore, that in such cases two radiograms will be needed—one taken with the dorsal, and the other with the plantar aspect uppermost, the conditions being otherwise precisely alike. A comparison of these should show whether the foreign object is nearer the dorsal or the plantar aspect of the foot.

"The second point refers to the three objects not seen clearly in the radiogram. The tube used was the ordinary 'shadow of the cross' one, and, though the cross was bent back, the shadow of its supports was visible; two of the objects were directly under this shadow. The third lay parallel and very close to a bone, and hence is not plainly distinguishable."

Photographs have been obtained by utilising other sources of luminosity than high vacuum tubes. The following experiments, performed by Messrs. Wm. Wallace and H. C. Pocklington in the Physical Laboratory of the Leeds Central Higher Grade School, are of interest:—

"A cheap German incandescent lamp of low candle-power was used in place of a Crookes' tube, a piece of tinfoil applied to the outside serving as one electrode, and the filament as the other. The current employed was the high frequency one obtained from a Tesla coil actuated by a large Ruhmkorff. The sparking distance of the Tesla was about 5/8 inch. This apparatus gave a vivid green phosphorescence of the glass, which soon grew less, and in fifteen minutes had almost disappeared. Three exposures were made in succession, each of fifteen minutes: the first when the lamp was new; the second immediately afterwards, the lamp being tired by the previous exposure; for the third, the tinfoil electrode was shifted round about 90°, so as to utilise a fresh part of the surface of the glass. The three negatives were developed simultaneously; the first was good, the other two were under-exposed to about the same extent. In the last experiment, the green phosphorescence, though not as brilliant as in the first, was much more brilliant than in the second. This seems to show that the production of X-rays is due to some cause different from that which produces the phosphorescence."

Mr. J. W. Gifford has obtained photographs by Röntgen's methods, and also by means of the ordinary discharge of an induction coil. Replying to a suggestion that results obtained by him with metal discs were due to a "contact" phenomenon, and not to Röntgen's rays, he says:—

"I notice in your issue of February 13, p. 340, that Mr. Sydney D. Rowland thinks that he has evidence to prove that my results without a Crookes' tube were not due to the 'Röntgen rays.' I have already replied to his observations elsewhere (*British Medical Journal*); but will you allow me to say that I think the evidence he advances entirely turns on whether the electrograph was a shadow or an impression, or, in other words, whether surface markings of the objects electrographed were reproduced, or not. Now, the discs I used bore numbers stamped on them, but in no case were these numbers, or any surface markings whatever, to be found in the resulting negative, a print of which I enclose.

"With regard to what Mr. Rowland says about the objects, in his case, being behind or in front of the film, I would suggest that the discharge from a coil is an oscillatory one, and that glass is fairly transparent to the 'Röntgen rays,' almost as transparent as aluminium, in fact. But conditions are often so different, that I do not feel justified in criticising another man's work without having seen his experiments myself. I must, however, most emphatically disclaim any positive assertions in the present stage of the inquiry. I have, as far as I am aware, only mentioned tentatively what seem to me the general indications of my experiments up to now, and feel that in investigations of this kind the balance is generally in favour of one's first impressions being wrong.

"I do not know if you have observed that when Crookes' tubes are employed for the purpose, after about an hour's use they become coated, both above and below, with a thin layer of dust. This happens, at least, time after time in my own laboratory."

Mr. W. A. D. Rudge, writing from the Science, Art and Technical Schools, Plymouth, says that he has obtained a radiogram of a crayfish, and found the exoskeleton to be as transparent to the new radiations as glass and aluminium.

Our United States correspondent sends us descriptions of work being done in America, in continuation of Röntgen's discovery. He says very successful photographs have now been obtained by Prof. A. W. Wright, of Yale. Prof. Wright has photographed a piece of metal having a fracture which had been welded, but showed no flaw or line of puncture to the eye. The photograph, however, revealed the fracture. This last result was considered by ordnance officials of the Government to be of profound significance, as indicating a means of testing armour for hidden defects and discovering hidden flaws in machinery. Prof. John Trowbridge, of Cambridge, Mass., has also obtained some results. He arranged strips of glass an eighth-inch thick in a wooden box of inch board, and passed the rays through the board, thus obtaining a photograph of the strips of glass. By passing the rays through prisms of wood and of vulcanite he has confirmed the observation that they were not refracted.

THE MANUFACTURE OF ALUMINIUM BY ELECTROLYSIS.

AT the ordinary meeting of the Institution of Civil Engineers on Tuesday, February 11, a paper was read on "The Manufacture of Aluminium by Electrolysis, and the Plant at Niagara for its Extraction," by Mr. Alfred E. Hunt. The author's description of the ores of aluminium best fitted for electrolytic reduction to the metallic state, and of the general principles governing the extraction of the metal from its compounds, makes interesting reading.

The Hall process, which is that adopted by the Pittsburg Reduction Company, involves the direct electrolysis of the sesquioxide, alumina, dissolved in a molten bath of the mixed fluorides of aluminium, calcium and sodium. One cubic foot of the solvent serves for an hourly production of one pound of metallic aluminium, the bath used being capable of dissolving one-third of its own weight of alumina. The electrical energy required for extracting this amount of metal is 3730 watt-hours for the decomposition of the alumina, with a further supply to maintain the bath at the temperature necessary for the molten condition. The fluorides remain unchanged, so that the operation is continuous. The bath is made either from a mixture of fluorspar and cryolite, or from the artificial fluorides; and it may be fused in a separate vessel when starting work, or in the bath by the current itself. Alumina is added at frequent intervals to prevent too great a variation in the resistance of the bath, and the aluminium, as it is produced, is siphoned from beneath the layer of fluoride, where it collected, without interference with the progress of the operations. The oxygen of the alumina is liberated at the carbon anode, which, at the temperature of the bath (980° C.) oxidises to carbon monoxide. Outside the bath this is burnt at once to carbon dioxide, and is allowed to escape into the working apartment. The carbon anodes are consumed at nearly the same rate as the aluminium is produced, the amount being about two-thirds of the quantity actually used. The difference of potentials theoretically necessary for the separation of the constituents of alumina is about 2·8 volts, but a greater difference is due to the resistance of the bath. The pots employed are of iron with carbon linings, but these can be dispensed with if a high degree of purity is not required.

The chief impurities in the finished product are silicon and iron. These are derived from the alumina as well as from the carbon anodes. Aluminium can be produced containing $99\frac{3}{4}$ per cent. of the pure metal, and is regularly delivered with 99 per cent. The electrolytic baths are joined in series, the positive bar of the switch-board being joined to the carbon anode of one of the baths, and the last pot of the series being joined to the negative board of the switch-board. All the copper connections are necessarily very heavy, on account of the large currents employed.

The electrical energy is generated at the works of the Niagara Falls Power Company, and is conveyed, without the intervention of transformers, over a distance of about half a mile, by stranded copper cables $1\frac{1}{4}$ inches in diameter. The loss in transmission is about $1\frac{1}{2}$ per cent. of the energy conveyed.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—Mr. D. H. Nagel, Fellow of Trinity College, has been elected as a Delegate of Local Examinations in place of Mr. E. Chapman, Fellow of Magdalen College, resigned.

Mr. F. T. Richards, Fellow of Trinity College, has been re-elected a Curator of the Botanic Garden.

Mr. J. E. Marsh, M.A., Balliol College, has been reappointed Lecturer in Materia Medica and Pharmacology for the year 1896.